WHAT IS CLAIMED IS:

SubA17 1. An OFDM demodulation apparatus for demodulating an OFDM signal which includes a data symbol structured by a valid symbol period and a guard interval, and a specific synchronous symbol is included in the OFDM signal for every transmission frame and, the apparatus comprising:

an impulse response estimation part for estimating an impulse response from said OFDM signal;

an integration part for integrating a signal obtained by estimation in said impulse response estimation part;

a determination part for detecting symbol timing of said OFDM signal based on a value obtained by integration in said integration part;

a window timing generation part for generating, according to said symbol timing, window timing to provide said valid symbol period; and

a Fourier transformation part for subjecting said OFDM signal to Fourier transform according to said window timing.

2. The OFDM demodulation apparatus according to claim 1, when an identical waveform is periodically transmitted in said synchronous symbol for twice or more, said apparatus further comprising:

a delay part for delaying said OFDM signal for a

predetermined number of samplings;

a multiplication part for multiplying a signal obtained by delay in said delay part and said OFDM signal;

an averaging part for averaging a signal obtained by multiplication in said multiplication part;

a frequency error calculation part for calculating a frequency error based on a signal obtained by averaging in said averaging part;

a hold part for holding said frequency error according to said symbol timing; and

a frequency correction part for correcting a frequency shift of said OFDM signal according to said frequency error provided by said hold part, wherein

said Fourier transformation part subjects, to Fourier transform, said OFDM signal with frequency shift corrected by said frequency correction part according to said window timing.

3. The OFDM demodulation apparatus according to claim 1,

when an identical waveform is periodically transmitted in said synchronous symbol for twice or more, the apparatus further comprising:

a first delay part for delaying said OFDM signal (hereinafter, first OFDM signal) for a first predetermined number of samplings;

a first multiplication part for multiplying a signal

obtained by delay in said first delay part and said first OFDM signal;

a first averaging part for averaging a signal obtained by multiplication in said first multiplication part;

a first frequency error calculation part for calculating a first frequency error based on a signal obtained by averaging in said first averaging part;

a filter part for smoothing a signal obtained by multiplication in said first multiplication part;

an absolute value calculation part for calculating an absolute value of a signal obtained by smoothing in said filter part;

a first determination part for determining, according to said absolute value, a correlation between said first OFDM signal and the signal obtained by delay in said first delay part, and detecting symbol timing of said first OFDM signal;

a first hold part for holding said first frequency error according to said symbol timing detected by said first determination part;

a first frequency correction part for correcting a frequency shift of said first OFDM signal according to said first frequency error provided by said first hold part;

a second delay part for delaying, for a second predetermined number of samplings, said first OFDM signal with frequency shift corrected by the first frequency correction part (hereinafter,

second OFDM signal);

a second multiplication part for multiplying a signal obtained by delay in said second delay part and said second OFDM signal;

a second averaging part for averaging a signal obtained by multiplication in said second multiplication part;

a second frequency error calculation part for calculating a second frequency error based on a signal obtained by averaging in said second averaging part;

a second hold part for holding said second frequency error according to said symbol timing detected by said determination part; and

a second frequency correction part for correcting a frequency error of said second OFDM signal according to said second frequency error provided by said second hold part, wherein

said impulse response estimation part estimates the impulse response from said second OFDM signal, and

said Fourier transformation part subjects, to Fourier transform, said second OFDM signal with frequency shift corrected by said second frequency conversion part according to said window timing.

4. The OFDM demodulation apparatus according to claim 1, wherein

said integration part regards a time length of said guard

interval as an integration section, and integrates an incoming signal while sequentially shifting the location of the integration section with respect to the incoming signal.

5. The OFDM demodulation apparatus according to claim 1, wherein

said integration part regards a time length of said guard interval and a predetermined time length before and after the guard interval as an integration section, and by integrating an incoming signal while sequentially shifting the location of the integration section with respect to the incoming signal, responds before and after a rectangular impulse response in the time length of said guard interval.

6. The OFDM demodulation apparatus according to claim 1, wherein

said integration part regards a time length of said guard interval and a predetermined time length before and after the guard interval as an integration section, and by integrating an incoming signal while sequentially shifting the location of the integration section with respect to the incoming signal, responds monotonously increasing before a rectangular impulse response in the time length of said guard interval but monotonously decreasing thereafter.

7. The OFDM demodulation apparatus according to claim 1, wherein

said impulse response estimation part comprises:

a synchronous symbol generation part for generating a signal identical to said synchronous symbol;

a correlation part for calculating a signal indicating how the signal generated by said synchronous symbol generation part and said OFDM signal are correlated to each other; and

a correlation calculation part for calculating a correlation from the signal obtained by calculation in said correlation part.

8. The OFDM demodulation apparatus according to claim 1, wherein

said impulse response estimation part comprises:

a synchronous symbol generation part for generating a signal whose frequency domain is identical to said synchronous symbol;

a multiplication part for multiplying a signal provided by said Fourier transformation part and the signal provided by said synchronous symbol generation part;

an inverse Fourier transformation part for subjecting, to inverse Fourier transform, a signal obtained by multiplication in said multiplication part; and

a correlation calculation part for calculating a

correlation from a signal provided by said inverse Fourier transformation part.

9. The OFDM demodulation apparatus according to claim 7, wherein

said correlation calculation part calculates an absolute value of complex vector ($i$, $q$) of the incoming signal.

10. The OFDM demodulation apparatus according to claim 8, wherein

said correlation calculation part calculates an absolute value of complex vector ($i$, $q$) of the incoming signal.

11. The OFDM demodulation apparatus according to claim 7, wherein

said correlation calculation part calculates a sum of an absolute value of $i$ and an absolute value of $q$ from the complex vector ($i$, $q$) of the incoming signal.

12. The OFDM demodulation apparatus according to claim 8, wherein

said correlation calculation part calculates a sum of an absolute value of $i$ and an absolute value of $q$ from the complex vector ($i$, $q$) of the incoming signal.

13. The OFDM demodulation apparatus according to claim 7, wherein

said correlation calculation part calculates a sum of a square of *i* and a square of *q* from the complex vector (*i*, *q*) of the incoming signal.

14. The OFDM demodulation apparatus according to claim 8, wherein

said correlation calculation part calculates a sum of a square of *i* and a square of *q* from the complex vector (*i*, *q*) of the incoming signal.

15. The OFDM demodulation apparatus according to claim 3, wherein

said first determination part receives said absolute value calculated by said absolute value calculation part, detects a value for invariability thereof, and then detects the absolute value showing a predetermined proportion to the invariable value.

16. An OFDM demodulation apparatus for demodulating an OFDM signal in which a known pilot carrier being a reference phase is assigned to each of a plurality of predetermined subcarriers, the apparatus comprising:

a Fourier transformation part for subjecting said OFDM signal to Fourier transform;

a pilot carrier extraction part for extracting said pilot carriers from a signal obtained by Fourier transform in said Fourier transformation part;

a phase change calculation part for calculating a phase change of said extracted pilot carriers;

a window shift estimation part for estimating, according to said phase change, a shift of window timing indicating timing for operation of said Fourier transformation part; and

a window timing generation part for generating, according to the shift estimated in said window shift estimation part and symbol timing of said OFDM signal, said window timing which causes said Fourier transformation part to operate.

17. An OFDM demodulation apparatus for demodulating an OFDM signal in which every transmission frame is provided with a predetermined reference symbol, and a known pilot carrier being a reference phase is assigned to each of a plurality of predetermined subcarriers, the apparatus comprising:

a Fourier transformation part for subjecting said OFDM signal to Fourier transform;

a reference symbol generation part for generating a signal identical to said reference symbol;

a transmission path characteristic estimation part for estimating a transmission path characteristic based on the signal generated by said reference symbol generation part and a

Fourier-transformed signal in said Fourier transformation part;

an equalization part for equalizing the Fourier-transformed signal according to information about the transmission path characteristic provided by said transmission path characteristic estimation part;

a pilot carrier extraction part for extracting said pilot carriers from a signal obtained by equalization in said equalization part;

a phase change calculation part for calculating a phase change of said extracted pilot carriers;

a window shift estimation part for estimating, according to said phase change, a shift of window timing indicating timing for operation of said Fourier transformation part; and

a window timing generation part for generating, according to the shift estimated in said window shift estimation part and symbol timing of said OFDM signal, said window timing which causes said Fourier transformation part to operate.

18. The OFDM demodulation apparatus according to claim 17, further comprising:

a phase shift estimation part for estimating a phase shift of said OFDM signal according to said phase change; and

a transmission path information correction part for correcting, according to said phase shift, said information about the transmission path characteristic to be outputted from said

transmission estimation part to said equalization part.

19. The OFDM demodulation apparatus according to claim 18, wherein

said transmission path information correction part corrects said information about transmission path characteristic according to timing when a signal indicating the phase shift is provided by said window shift estimation part.

20. The OFDM demodulation apparatus according to claim 17, wherein

said window timing generation part generates, according to the shift estimated in said window shift estimation part, said window timing while shifting said symbol timing for a predetermined number of samplings.

21. The OFDM demodulation apparatus according to claim 17, further comprising:

a phase shift estimation part for estimating a phase shift of said OFDM signal according to said phase change; and

a phase correction part for correcting a phase of the signal provided by said equalization part based on said phase shift.

22. An OFDM demodulation method for demodulating an OFDM signal which includes a data symbol structured by a valid symbol

period and a guard interval, and a specific synchronous symbol is included in the OFDM signal for every transmission frame and, the method comprising the steps of:

estimating an impulse response from said OFDM signal;

integrating a signal obtained by estimation;

detecting symbol timing of said OFDM signal based on a value obtained by integration in said integration part;

generating window timing to provide said valid symbol period based on said symbol timing; and

Fourier-transforming said OFDM signal according to said window timing.

23. The OFDM demodulation method according to claim 22, when an identical waveform is periodically transmitted in said synchronous symbol for twice or more, the method further comprising the steps of:

delaying said OFDM signal for a predetermined number of samplings;

multiplying a signal obtained by delay in said delay part and said OFDM signal;

averaging a signal obtained by multiplication in said multiplication part;

calculating a frequency error based on a signal obtained by averaging in said averaging part;

holding said frequency error according to said symbol

timing; and

correcting a frequency shift of said OFDM signal according to said frequency error provided in said holding step, wherein

in said Fourier-transform step, said OFDM signal with frequency shift corrected is subjected to Fourier transform according to said window timing.

24. The OFDM demodulation method according to claim 22,

when an identical waveform is periodically transmitted in said synchronous symbol for twice or more, the method further comprising :

a first delay step of delaying said OFDM signal (hereinafter, first OFDM signal) for a first predetermined number of samplings;

a first multiplication step of multiplying a signal obtained by delay in said first delay step and said first OFDM signal;

a first averaging step of averaging a signal obtained by multiplication in said first multiplication step;

a step of calculating a first frequency error based on a signal obtained by averaging in said first averaging step;

a step of smoothing a signal obtained by multiplication in said first multiplication step;

a step of calculating an absolute value of a signal obtained by smoothing in smoothing step;

a first determination step of determining, according to

said absolute value, a correlation between said first OFDM signal and the signal obtained by delay in said first delay step, and detecting symbol timing of said first OFDM signal;

a step of holding said first frequency error according to said symbol timing detected in said first determination step;

a step of correcting a frequency shift of said first OFDM signal according to said first frequency error held;

a second delay step of delaying, for a second predetermined number of samplings, said first OFDM signal with frequency shift corrected (hereinafter, second OFDM signal);

a second multiplication step of multiplying a signal obtained by delay in said second delay step and said second OFDM signal;

a second averaging step of averaging a signal obtained by multiplication in said second multiplication step;

a step of calculating a second frequency error based on a signal obtained by averaging in said second averaging step;

a step of holding said second frequency error according to said symbol timing detected in said determination step; and

a step of correcting a frequency shift of said second OFDM signal according to said second frequency error held, wherein

in said estimating step, an impulse response is estimated from said second OFDM signal, and

in said Fourier-transform step, according to said window timing, said second OFDM signal with frequency shift corrected

is subjected to Fourier transform.

25. The OFDM demodulation method according to claim 22, wherein

in said integrating step, a time length of said guard interval is regard as an integration section, and an incoming signal is integrated while the location of the integration section being sequentially shifted with respect to the incoming signal.

26. The OFDM demodulation method according to claim 22, wherein

in said integrating step, a time length of said guard interval and a predetermined time length before and after the guard interval are regarded as an integration section, and by integrating an incoming signal while sequentially shifting the location of the integration section with respect to the incoming signal, a response is provided before and after a rectangular impulse response having the time length of said guard interval.

27. The OFDM demodulation method according to claim 22, wherein

in said integrating step, a time length of said guard interval and a predetermined time length before and after the guard interval are regarded as an integration section, and by integrating an incoming signal while sequentially shifting the

location of the integration section with respect to the incoming signal, a response which monotonously increasing before a rectangular impulse response having the time length of said guard interval but monotonously decreasing thereafter is provided.

28. The OFDM demodulation method according to claim 22, wherein

said estimating step comprises the steps of:

generating a signal identical to said synchronous symbol;

calculating a signal indicating a correlation between a signal generated in said generating step and said OFDM signal; and

calculating a correlation from a signal obtained in said calculating step.

29. The OFDM demodulation method according to claim 22, wherein

said estimating step comprises the steps of:

generating a frequency-domain signal identical to said synchronous symbol;

multiplying a signal obtained in said Fourier-transform step and the frequency-domain signal generated in said generating step;

inverse-Fourier-transforming a signal obtained in said multiplying step; and

calculating a correlation from said inverse-Fourier-transformed signal.

30. The OFDM demodulation method according to claim 28, wherein

in said calculating step, an absolute value of complex vector ($i$, $q$) of the incoming signal is calculated.

31. The OFDM demodulation method according to claim 29, wherein

in said calculating step, an absolute value of complex vector ($i$, $q$) of the incoming signal is calculated.

32. The OFDM demodulation method according to claim 28, wherein

in said calculating step, a sum of an absolute value of $i$ and an absolute value of $q$ is calculated from the complex vector ($i$, $q$) of the incoming signal.

33. The OFDM demodulation method according to claim 29, wherein

in said calculating step, a sum of an absolute value of $i$ and an absolute value of $q$ is calculated from the complex vector ($i$, $q$) of the incoming signal.

34. The OFDM demodulation method according to claim 28, wherein

in said calculating step, a sum of a square of $i$ and a square of $q$ is calculated from the complex vector $(i, q)$ of the incoming signal.

35. The method for OFDM demodulation according to claim 29, wherein

in said calculating step, a sum of a square of $i$ and a square of $q$ is calculated from the complex vector $(i, q)$ of the incoming signal.

36. The OFDM demodulation method according to claim 24, wherein

in said first determination step, a value for invariability of said absolute value is detected, and then the absolute value showing a predetermined proportion to the invariable value is detected.

37. An OFDM demodulation method for demodulating an OFDM signal in which a known pilot carrier being a reference phase is assigned to each of a plurality of predetermined subcarriers, the method comprising the steps of:

Fourier-transforming said OFDM signal;

extracting said pilot carriers from said Fourier-

transformed signal;

calculating a phase change of said extracted pilot carriers;

estimating, according to said phase change, a shift of window timing indicating timing for Fourier transform; and

generating, according to said estimated shift and symbol timing of said OFDM signal, said window timing for Fourier transform with respect to said OFDM signal.

38. An OFDM demodulation method for demodulating an OFDM signal in which every transmission frame is provided with a predetermined reference symbol, and a known pilot carrier being a reference phase is assigned to each of a plurality of predetermined subcarriers, the method comprising the steps of:

Fourier-transforming said OFDM signal;

generating a signal identical to said reference symbol;

estimating a transmission path characteristic based on said generated signal and said Fourier-transformed signal;

equalizing said Fourier-transformed signal according to information about the transmission path characteristic obtained in said estimating step;

extracting said pilot carriers from said equalized signal;

calculating a phase change of said extracted pilot carriers;

estimating, according to said phase change, a shift of

window timing indicating timing for Fourier transform; and

generating, according to said estimated shift and symbol timing of said OFDM signal, said window timing for Fourier transform with respect to said OFDM signal.

39. The OFDM demodulation method according to claim 38, further comprising the steps of:

estimating a phase shift of said OFDM signal according to said phase change; and

correcting said information about transmission path characteristic according to said phase shift.

40. The OFDM demodulation method according to claim 39, wherein

in said correcting step, said information about transmission path characteristic is corrected according to timing when a signal indicating the phase shift is provided after estimated in said estimating step.

41. The OFDM demodulation method according to claim 38, wherein

in said window-timing-generating step, said window timing is generated while shifting said symbol timing for a predetermined number of timings according to said estimated shift.

42. The OFDM demodulation method according to claim 38, further comprising the steps of:

estimating a phase shift of said OFDM signal according to said phase change; and

correcting a phase of a signal provided after equalization in said equalizing step based on said phase shift.

Add A17